



Pediatric Diabetic Ketoacidosis (DKA)

Early Diagnosis & Early Stabilization

Supervised by Dr. Amir Naghshzan (AmirNaghshzan@gmail.com)

1. Definition

Diabetic ketoacidosis (DKA) is an acute metabolic emergency characterized by the combination of:

Hyperglycemia + ketosis + metabolic acidosis

In children, DKA may be the **first presentation of type 1 diabetes**, but it can also occur in children with established diabetes.

Diagnostic triad

Glucose ↑ + Ketones ↑ + Acidosis

A practical pediatric definition is:

- Plasma glucose **>11 mmol/L** (≈ 200 mg/dL)
- Blood β -hydroxybutyrate **>3 mmol/L** or significant ketonuria
- Venous/arterial **pH <7.30 or bicarbonate <15 mmol/L** ([Nice](#))

Important: DKA can occasionally occur with relatively normal glucose, particularly in patients receiving insulin or certain glucose-lowering therapies (**euglycemic DKA**). ([Nice](#))

2. Clinical Presentation

Think DKA when a child has:

Classic diabetes symptoms

- Polyuria
- Polydipsia

- Nocturia/enuresis
- Weight loss
- Fatigue

Features suggesting DKA

- Nausea and vomiting
- Abdominal pain
- Dehydration
- Tachypnea
- **Kussmaul breathing**
- Fruity/acetone breath
- Weakness
- Altered mental status

Severe disease

- Marked dehydration
- Hypotension/shock
- Reduced consciousness
- Severe acidosis
- Poor peripheral perfusion

A very important clinical clue

A child with **vomiting + abdominal pain + tachypnea** may initially be diagnosed with gastroenteritis or an acute abdomen.

Always check:

Blood glucose $\pm$ ketones

before accepting these diagnoses.

3. Diagnostic Approach

Step 1 — Recognize the possibility

Ask:

Could this be diabetes/DKA?

Especially in a child with:

Polyuria + polydipsia + weight loss

OR

Vomiting + abdominal pain + deep breathing

OR

Altered consciousness without an obvious cause

Step 2 — Immediate bedside tests

Do immediately:

- Capillary blood glucose
- Blood β -hydroxybutyrate if available
- Venous blood gas
- Pulse oximetry
- Vital signs
- Weight

If DKA is suspected, **do not delay referral or stabilization while waiting for confirmatory tests.**

NICE recommends immediate hospital assessment when DKA is suspected. ([Nice](#))

Step 3 — Confirm DKA

Think:

Hyperglycemia + Ketosis + Acidosis

Finding	Typical DKA
Glucose	>200 mg/dL
β -hydroxybutyrate	>3 mmol/L
pH	<7.30
HCO ₃ ⁻	<15 mmol/L

Severity

Severity	pH	HCO ₃ ⁻
Mild	<7.30	<15
Moderate	<7.20	<10
Severe	<7.10	<5

For students: severity is primarily determined by the **degree of acidosis**, not simply by the glucose level.

4. Differential Diagnosis

DKA is particularly important because several conditions can produce **vomiting, abdominal pain, tachypnea, and altered consciousness**.

Important differentials

- Sepsis/septic shock
- Gastroenteritis with dehydration
- Lactic acidosis/shock
- Toxic ingestion
- Salicylate poisoning
- Starvation ketosis
- Hyperosmolar hyperglycemic state (HHS)
- Renal failure
- Inborn errors of metabolism
- Acute abdomen
- Pneumonia/severe respiratory infection

Key distinction

DKA:

Ketosis + metabolic acidosis

HHS:

Very severe hyperglycemia/hyperosmolality with **little or no significant ketosis/acidosis**.

5. Investigations

Essential investigations

Bedside

- Capillary glucose
- Blood β -hydroxybutyrate
- Vital signs
- Neurological assessment
- Weight

Blood

- Venous blood gas
- Sodium
- Potassium
- Chloride
- Bicarbonate
- Urea/BUN
- Creatinine
- Glucose
- β -hydroxybutyrate
- Calcium $\pm$ phosphate/magnesium according to local protocol

Additional investigations when indicated

- CBC
- CRP/cultures if infection suspected
- ECG, particularly with significant potassium abnormalities
- HbA1c
- Diabetes-specific tests after stabilization when appropriate

Calculate the anion gap

$$\text{Anion gap} = \text{Na}^+ - (\text{Cl}^- + \text{HCO}_3^-)$$

DKA typically produces:

High anion-gap metabolic acidosis

The anion gap is useful for understanding the metabolic abnormality, but **ketone clearance and clinical improvement are more important indicators of resolution than glucose normalization alone.**

Corrected sodium

Hyperglycemia lowers the measured serum sodium.

Therefore, monitor sodium during treatment and interpret it in the context of the glucose level.

A **falling sodium during treatment**, particularly with neurological deterioration, should raise concern for cerebral injury. ([Nice](#))

6. Management Algorithm

 **DKA = ABCDE + Fluids + Potassium + Insulin + Monitoring**

STEP 1 — ABCDE stabilization

A — Airway

Assess consciousness and ability to protect the airway.

If markedly reduced consciousness:

- Urgent senior/critical-care assessment
- Consider airway protection
- Avoid unnecessary intubation because ventilation changes can worsen acidosis if not carefully managed.

B — Breathing

Look for:

Kussmaul respiration = compensatory response to metabolic acidosis

Do not mistake Kussmaul breathing for primary respiratory disease.

C — Circulation

Assess:

- Heart rate
 - Blood pressure
 - Capillary refill
 - Peripheral pulses
 - Temperature
 - Urine output
 - Clinical dehydration
-

STEP 2 — IV access and fluids

If clinically dehydrated but not in shock

Give:

0.9% NaCl 10 mL/kg IV over ~30 minutes

Then reassess perfusion and clinical status.

NICE recommends discussing additional boluses with a senior pediatrician and limiting additional boluses to children who remain poorly perfused. ([Nice](#))

If shock is present

This is a **critical-care emergency**.

Give an initial isotonic crystalloid bolus and reassess frequently, with early involvement of pediatric critical care.

NICE currently recommends **10 mL/kg of 0.9% saline** initially in children with signs of shock. ([Nice](#))

Important principle

Do **not** give repeated large fluid boluses simply because the child has tachycardia or prolonged capillary refill.

These findings can occur from severe acidosis and do not necessarily mean shock. ([Nice](#))

STEP 3 — Potassium

This is one of the most important treatment principles.

Although serum potassium may initially be:

Normal or high

the child usually has **total-body potassium depletion**.

Why?

Insulin + correction of acidosis $\rightarrow$ K^+ moves into cells $\rightarrow$ serum K^+ falls

Therefore:

Before insulin

Check potassium and urine output.

If potassium is significantly low

Correct potassium before starting insulin.

If potassium is acceptable and the child is producing urine

Potassium is generally added to IV fluids according to the institutional pediatric DKA protocol.

NICE recommends potassium supplementation in DKA fluids unless there is anuria or significant hyperkalemia. ([Nice](#))

STEP 4 — Insulin

Start insulin after initial fluid resuscitation

Typical pediatric IV insulin:

0.05–0.1 units/kg/hour

Important

Do NOT give an IV insulin bolus routinely.

Insulin should be continued to suppress ketogenesis and close the metabolic disturbance, even after glucose begins to normalize. ([Nice](#))

STEP 5 — Add glucose when glucose falls

A common mistake is:

"Glucose is normal → stop insulin."

✗ Wrong.

The problem is not only hyperglycemia.

The problem is:

Ketosis + acidosis

Therefore, when glucose falls sufficiently, **add dextrose to the IV fluid while continuing insulin.**

This allows continued insulin therapy until ketosis resolves. NICE recommends adding glucose once plasma glucose falls below approximately **14 mmol/L ($\approx$ 250 mg/dL)**. ([Nice](#))

STEP 6 — Monitor continuously

At least hourly

- Glucose
- Heart rate
- Blood pressure
- Respiratory rate
- Neurological status
- Fluid input/output

Repeatedly monitor:

- pH/bicarbonate
- Electrolytes
- Potassium
- Sodium
- Ketones

NICE specifically recommends at least hourly clinical and glucose monitoring during pediatric DKA treatment. ([Nice](#))

STEP 7 — Look continuously for cerebral injury

Must not miss

Possible early manifestations:

- Headache
- Irritability/agitation
- Unexpected fall in heart rate
- Rising blood pressure
- Altered mental status
- Reduced consciousness
- Abnormal respiratory pattern

These findings require **immediate assessment and treatment** rather than waiting for brain imaging. ([Nice](#))

Key principle

Neurological deterioration during DKA is an emergency.

Do not wait for CT to start appropriate treatment if cerebral injury is strongly suspected.

STEP 8 — When is DKA resolving?

Do not use glucose alone.

Improvement should include:

- Ketosis resolving
- Acidosis resolving
- Patient becoming alert
- Able to tolerate oral fluids
- Stable circulation

Only then should IV insulin be transitioned to subcutaneous insulin.

NICE recommends giving subcutaneous insulin **at least 30 minutes before stopping IV insulin.** ([Nice](#))

7. Drug & Fluid Summary Table

Treatment	Practical approach	Key point
0.9% NaCl	Initial isotonic fluid; commonly 10 mL/kg bolus when indicated	Reassess after bolus
IV insulin	0.05–0.1 U/kg/h	No routine IV bolus
KCl	Add to fluids when appropriate	Check K ⁺ and urine output
Dextrose	Add when glucose falls while ketosis persists	Do not stop insulin just because glucose falls
NaHCO ₃	Generally not recommended	Consider only exceptional life-threatening circumstances with critical-care input
Mannitol / hypertonic saline	For suspected cerebral injury according to pediatric emergency/critical-care protocol	Treat clinically; do not wait for CT

NICE specifically recommends against routine IV bicarbonate and limits its consideration to exceptional circumstances involving severe acidosis/life-threatening hyperkalemia with compromised cardiac contractility and pediatric critical-care involvement. ([Nice](#))

8. Admission Criteria

All children with confirmed DKA

Hospital admission is required.

DKA requires:

- IV therapy
- Frequent glucose/electrolyte monitoring
- Neurological monitoring
- Continuous reassessment

Higher-acuity care

Consider PICU/HDU or equivalent pediatric critical-care setting for:

- Severe DKA
- Altered consciousness
- Suspected cerebral injury
- Shock
- Significant electrolyte abnormalities
- Very young children, particularly <2 years
- Respiratory compromise
- Significant comorbidity
- Inability to protect airway

NICE recommends one-to-one nursing/HDU-level care particularly for children younger than 2 years and those with severe DKA. ([Nice](#))

9. Referral Criteria

From outpatient/primary care/ED

Immediate hospital referral if DKA is suspected.

Urgent pediatric/endocrine referral

- New suspected type 1 diabetes
- Hyperglycemia with ketones
- Recurrent ketosis
- Unexplained weight loss/polyuria/polydipsia

Urgent PICU/critical-care referral

- Shock
- Reduced consciousness
- Suspected cerebral injury
- Severe acidosis
- Significant potassium abnormality
- Respiratory or airway compromise

Consider sepsis

In a child with DKA, suspect an additional infection/sepsis when there is:

- Fever/hypothermia

- Hypotension
- Lactate elevation
- Refractory acidosis
- Clinical evidence of infection

([Nice](#))

10. Follow-up

After recovery from DKA:

Identify the precipitating factor

Ask:

- Was this new-onset diabetes?
- Infection?
- Missed insulin?
- Insulin pump failure?
- Incorrect insulin administration?
- Psychosocial/adherence problems?
- Intercurrent illness?

Before discharge

The patient/family should understand:

- Insulin administration
- Glucose monitoring
- Ketone monitoring
- Sick-day rules
- Recognition of hypoglycemia
- Recognition of recurrent ketosis
- When to seek emergency care

NICE recommends structured education and sick-day management after DKA. ([Nice](#))

11. Clinical Pearls

★ Pearl 1

DKA may be the first presentation of diabetes.

★ Pearl 2

A child with:

vomiting + abdominal pain + tachypnea

should have a **blood glucose checked**.

★ Pearl 3

Kussmaul breathing is compensation for metabolic acidosis, not necessarily primary pulmonary disease.

★ Pearl 4

The severity of DKA is determined mainly by **acidosis**, not simply by the glucose concentration.

★ Pearl 5

A normal or high serum potassium **does not mean total-body potassium is normal**.

★ Pearl 6

Never stop insulin simply because glucose has normalized if significant ketosis persists.

Instead:

Add glucose → continue insulin → clear ketones.

★ Pearl 7

Routine bicarbonate is **not part of pediatric DKA treatment**. ([Nice](#))

★ Pearl 8

Neurological deterioration during DKA should be treated as **possible cerebral injury until proven otherwise**.

★ Pearl 9

Do not wait for CT before treating clinically suspected cerebral injury.

★ Pearl 10

The goal is not simply:

"Normalize glucose."

The goal is:

Restore perfusion + correct electrolytes + suppress ketogenesis + resolve acidosis safely.

12. Common Mistakes in Exams and Practice

✗ Common mistake	✓ Correct approach
Diagnosing gastroenteritis in a child with vomiting and tachypnea	Check glucose and ketones
Assuming DKA requires extremely high glucose	DKA can occur with less marked hyperglycemia
Starting insulin before assessing potassium	Check K ⁺ first
Giving an insulin bolus routinely	Use continuous IV insulin
Stopping insulin when glucose normalizes	Add dextrose and continue insulin while ketosis persists
Treating serum hyperkalemia as adequate total-body potassium	Remember total-body K ⁺ depletion
Giving bicarbonate routinely	Avoid routine bicarbonate
Treating tachycardia as definite shock	Assess perfusion and hemodynamics
Focusing only on glucose	Follow ketones, pH/HCO ₃ ⁻ and clinical status
Ignoring neurological changes	Suspect cerebral injury immediately
Waiting for CT before treating cerebral injury	Treat clinically suspected cerebral injury immediately
Transitioning to SC insulin too early	Wait until ketosis/acidosis are resolving and oral intake is adequate

The large PECARN randomized trial found no significant difference in neurologic outcomes based on the tested IV fluid infusion rate or sodium chloride concentration, reinforcing that the focus should be on **appropriate, monitored fluid resuscitation rather than excessive fear of necessary fluids**. ([New England Journal of Medicine](#))

13. Key Take-Home Messages

Remember "DKA = 5 things"

1. **Recognize it early**
Polyuria/polydipsia/weight loss or vomiting + abdominal pain + tachypnea → check glucose.
 2. **Confirm the triad**
Hyperglycemia + ketosis + metabolic acidosis.
 3. **Stabilize first**
ABCDE, IV access, isotonic fluid, electrolytes and monitoring.
 4. **Insulin clears ketones**
Start IV insulin after initial fluid resuscitation and appropriate potassium assessment.
 5. **Never forget potassium**
Serum K⁺ may look normal/high despite major total-body depletion.
 6. **Glucose falling does not mean DKA is cured**
Add dextrose and continue insulin until ketosis resolves.
 7. **Neurological deterioration = emergency**
Think cerebral injury and treat immediately.
 8. **Avoid routine bicarbonate.**
 9. **Search for the precipitating cause**
Especially infection, missed insulin, pump failure or new-onset diabetes.
 10. **The endpoint is metabolic recovery, not merely a normal glucose.**
-

One-Minute DKA Algorithm for the Ward/ED

Child with vomiting ± abdominal pain ± tachypnea ± polyuria/polydipsia

↓

Check glucose + ketones

↓

Glucose ↑ + ketones ↑ + pH/HCO₃⁻ abnormal

↓

DKA → ABCDE + senior pediatric help

↓

IV access + isotonic fluid + electrolytes

↓

Check K⁺ and urine output

↓

IV insulin 0.05–0.1 U/kg/h

↓

Monitor glucose, K⁺, Na⁺, pH/ketones + neurological status

↓

Glucose falls → ADD DEXTROSE

↓

Continue insulin until ketosis/acidosis resolve

↓

Neurological deterioration? → Treat suspected cerebral injury immediately

↓

Alert + tolerating oral intake + ketosis resolving → transition to SC insulin

Core references

- **ISPAD Clinical Practice Consensus Guidelines 2022 — Chapter 11: Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar State.** ([ISPAD](#))
- **NICE NG18: Diabetes in children and young people — DKA recommendations,** including diagnosis, fluid therapy, insulin, potassium, monitoring and cerebral injury. ([Nice](#))
- Kuppermann N, et al. **Clinical Trial of Fluid Infusion Rates for Pediatric Diabetic Ketoacidosis.** *N Engl J Med.* 2018;378:2275–2287. ([New England Journal of Medicine](#))